NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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POWER-OFF WIND-TUNNEL TESTS OF THE 1/8-SCALE MODEL OF THE BREWSTER F2A AIRPLANE

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NACA

WASHINGTON

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

MEMORANDUM REPORT

for the

Bureau of Aeronautics, Navy Department

POWER-OFF WIND-TUNNEL TESTS OF THE 1/8-SCALE MODEL OF THE BREWSTER F2A AIRPLANE

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INTRODUCTION

At the request of the Bureau of Aeronautics, Navy Department, tests were made in the 7- by 10-foot wind tunnel of the 1/8-scale model of the Brewster F2A airplane. The object of the tests was to determine the power-off static lateral and longitudinal stability and control of the complete model.

MODEL

The 1/8-scale model of the Brewster F2A airplane was furnished by the Brewster Aeronautical Corporation and no attempt was made to check its dimensions. A three-view drawing of the complete model with the original wing is shown in figure 1 and a three-view drawing of the modified wing is shown in figure 1(a). The modified wing has a full-span NACA slotted flap and both plain and slot-lip ailerons.

The angle of attack of the reference line was determined by means of leveling lugs that were fitted into holes previously drilled in the fuselage. The stabilizer, elevator, rudder, flap, and aileron angles were set by means of templets furnished with the model.

TESTS AND RESULTS

Test conditions.- The tests were made in the NACA 7- by 10-foot wind tunnel. All the tests were run at a dynamic pressure of 16.37 pounds per square foot which corresponds to a velocity of about 80 miles per hour under standard sea-level conditions, and to a test Reynolds number of about 570,000 based on the mean aerodynamic

chord of 9.36 inches. The effective Reynolds number, R_e, was 912,000 based on a turbulence factor for the 7- by 10-foot tunnel of 1.6.

Coefficients.- The results of the tests are given in the form of standard NACA coefficients of forces and moments based on model wing area, wing span, and mean aerodynamic chord. All moments are taken about the center-of-gravity location of the complete airplane shown on figure 1 (normal fighter landing gear retracted). The data are referred to the stability axes, a system in which the X axis is the intersection of the plane of symmetry of the airplane with a plane perpendicular to the plane of symmetry and parallel with the relative wind direction, the Y axis is perpendicular to the plane of symmetry, and the Z axis is in the plane of symmetry and perpendicular to the X axis. The coefficients are defined as follows:

C_D drag coefficient $= \frac{X}{qS}$

C_Y lateral-force coefficient $= \frac{Y}{qS}$

C_L lift coefficient $= \frac{L}{qS}$

C_l rolling-moment coefficient about c.g. $= \frac{l}{qSb}$

C_m pitching-moment coefficient about c.g. $= \frac{m}{qSc}$

C_n yawing-moment coefficient about c.g. $= \frac{n}{qSb}$

where

X force along X axis; positive when directed backwards

Y force along Y axis; positive when directed to right

L force along Z axis; positive when directed upwards

l rolling moment about X axis; positive when it tends to depress the right wing

m pitching moment about Y axis; positive when it tends to depress the tail

n yawing moment about Z axis; positive when it tends to retard right wing

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q dynamic pressure = $\frac{1}{2}\rho V^2$ (16.37 pounds per square foot)

S wing area (3.265 square feet)

c mean aerodynamic chord (0.78 foot)

b wing span (4.38 feet)

Symbols.- Certain symbols are used in the text and figures and are defined as follows:

α angle of attack of thrust line, degrees

ψ angle of yaw, degrees; positive when nose of model moves to right

i_T angle of stabilizer setting with respect to thrust line, degrees; positive with trailing edge down

δ_e elevator deflection (with respect to stabilizer chord), degrees; positive when trailing edge of elevator is moved down

δ_r rudder deflection, degrees; positive when trailing edge of rudder is moved to left

δ_f flap deflection, degrees; positive when trailing edge of flap is moved down

δ_{a_p} plain aileron deflection, degrees; positive when trailing edge of aileron is moved down (subscripts R and L denote right and left ailerons)

$\delta_{a_{SL}}$ slot-lip aileron deflection, degrees; positive when trailing edge of aileron is moved down (subscripts R and L denote right and left ailerons)

Corrections.- The results have not been corrected for tares caused by the model support.

All the angles of attack, the drag coefficients, and the pitching-moment coefficients have been corrected for the effects of the tunnel walls. The jet-boundary corrections applied were computed as follows:

Induced drag correction, $\Delta C_{D_i} = \delta \frac{S}{C} C_L^2$ (1)

Induced angle-of-attack correction, $\Delta \alpha_i{}^{\circ} = \delta \frac{S}{C} C_L(57.3)$ (2)

Pitching-moment-coefficient correction

$$\Delta C_m = \delta_{a_W} \frac{S}{C} \frac{dC_m}{di_T} C_L(57.3) \tag{3}$$

All corrections are added to tunnel data. In the above equations:

$\delta = 0.115$

$\delta_{a_W} = 0.065$

C = tunnel cross-sectional area (69.59 square feet)

$\frac{dC_m}{di_T}$ = change in pitching-moment coefficient per degree change in stabilizer setting. (This slope was furnished by contractor from New York University data.)

No jet-boundary corrections were applied to the yawing- and rolling-moment coefficients. The corrections to the rolling- and yawing-moment coefficients are negligible for the size of the model used.

For convenience in locating test results, a résumé of the tests and of the figures in which the results are presented is given in the following table:

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TABLE I.

Test No.	Model Designation	δ_e	δ_r	δ_f	Aileron def. (plain)	Aileron def. (slot-lip)		Type Test	Figure No.
1	Complete Model with Original Wing	0	0	0	0	None	$\psi = 0$	Pitch	2,6
2	do	0	0	0	$\frac{1}{2}$ full	do	$\psi = 0$	do	6
3	do	0	0	0	$\frac{3}{4}$ full	do	$\psi = 0$	do	6
4	do	0	0	0	full	do	$\psi = 0$	do	6
5	do	0	0	30	0	do	$\psi = 0$	do	2,7
6	do	0	0	30	$\frac{1}{2}$ full	do	$\psi = 0$	do	7
7	do	0	0	30	$\frac{3}{4}$ full	do	$\psi = 0$	do	7
8	do	0	0	30	full	do	$\psi = 0$	do	7
9	do	0	0	60	0	do	$\psi = 0$	do	2,8
10	do	0	0	60	$\frac{1}{2}$ full	do	$\psi = 0$	do	8
11	do	0	0	60	$\frac{3}{4}$ full	do	$\psi = 0$	do	8
12	do	0	0	60	full	do	$\psi = 0$	do	8
13	Complete Model with Modified Wing	0	0	0	0	0	$\psi = 0$	do	3,9
14	do	0	0	0	$\frac{1}{2}$ full	0	$\psi = 0$	do	9
15	do	0	0	0	$\frac{3}{4}$ full	0	$\psi = 0$	do	9
16	do	0	0	0	full	0	$\psi = 0$	do	9
17	do	0	0	10	0	0	$\psi = 0$	do	3,10
18	do	0	0	10	$\frac{1}{2}$ full	0	$\psi = 0$	do	10
19	do	0	0	10	$\frac{3}{4}$ full	0	$\psi = 0$	do	10
20	do	0	0	10	full	0	$\psi = 0$	do	10
21	do	0	0	20	0	0	$\psi = 0$	do	3,11,15
22	do	0	0	20	$\frac{1}{2}$ full	0	$\psi = 0$	do	11
23	do	0	0	20	$\frac{3}{4}$ full	0	$\psi = 0$	do	11
24	do	0	0	20	full	0	$\psi = 0$	do	11
25	do	0	0	20	0	$\frac{1}{2}$ full	$\psi = 0$	do	15
26	do	0	0	20	0	$\frac{3}{4}$ full	$\psi = 0$	do	15
27	do	0	0	20	0	full	$\psi = 0$	do	15
28	do	0	0	30	0	0	$\psi = 0$	do	3,4,12,16
29	do	0	0	30	0	$\frac{1}{8}$ full	$\psi = 0$	do	16
30	do	0	0	30	0	$\frac{1}{4}$ full	$\psi = 0$	do	16

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TABLE I .- Concluded.

Test No.	Model Designation	δ_e	δ_r	δ_f	Aileron def. (plain)	Aileron def. (slot-lip)		Type Test	Figure No.
31	Complete model with Modified wing	0	0	30	0	$\frac{1}{2}$ full	$\psi = 0$	Pitch	16
32	do	0	0	30	0	$\frac{3}{4}$ full	$\psi = 0$	do	16
33	do	0	0	30	0	full	$\psi = 0$	do	16
34	do	0	0	30	$\frac{1}{2}$ full	0	$\psi = 0$	do	12
35	do	0	0	30	full	0	$\psi = 0$	do	12
36	do	0	0	40	0	0	$\psi = 0$	do	3,13,17
37	do	0	0	40	0	$\frac{1}{2}$ full	$\psi = 0$	do	17
38	do	0	0	40	0	$\frac{3}{4}$ full	$\psi = 0$	do	17
39	do	0	0	40	0	full	$\psi = 0$	do	17
40	do	0	0	40	$\frac{1}{2}$ full	0	$\psi = 0$	do	13
41	do	0	0	40	full	0	$\psi = 0$	do	13
42	do	0	0	50	0	0	$\psi = 0$	do	3,5,14,18
43	do	0	0	50	0	$\frac{1}{8}$ full	$\psi = 0$	do	18
44	do	0	0	50	0	$\frac{1}{4}$ full	$\psi = 0$	do	18
45	do	0	0	50	0	$\frac{1}{2}$ full	$\psi = 0$	do	18
46	do	0	0	50	0	$\frac{3}{4}$ full	$\psi = 0$	do	18
47	do	0	0	50	0	full	$\psi = 0$	do	18
48	do	0	0	50	$\frac{1}{2}$ full	0	$\psi = 0$	do	14
49	do	0	0	50	full	0	$\psi = 0$	do	14
50	do	-15	0	50	0	0	$\psi = 0$	do	5
51	do	-30	0	50	0	0	$\psi = 0$	do	5
52	do	-15	0	30	0	0	$\psi = 0$	do	4
53	do	-30	0	30	0	0	$\psi = 0$	do	4
54	do	0	0	50	0	0	$\alpha = 10^{\circ}$	yaw	20
55	do	0	-10	50	0	0	$\alpha = 10^{\circ}$	do	20
56	do	0	-15	50	0	0	$\alpha = 10^{\circ}$	do	20
57	do	0	-20	50	0	0	$\alpha = 10^{\circ}$	do	20
58	do	0	0	10	0	0	$\alpha = 10^{\circ}$	do	19
59	do	0	-15	10	0	0	$\alpha = 10^{\circ}$	do	19
60	do	0	-10	10	0	0	$\alpha = 10^{\circ}$	do	19
61	do	0	-20	10	0	0	$\alpha = 10^{\circ}$	do	19

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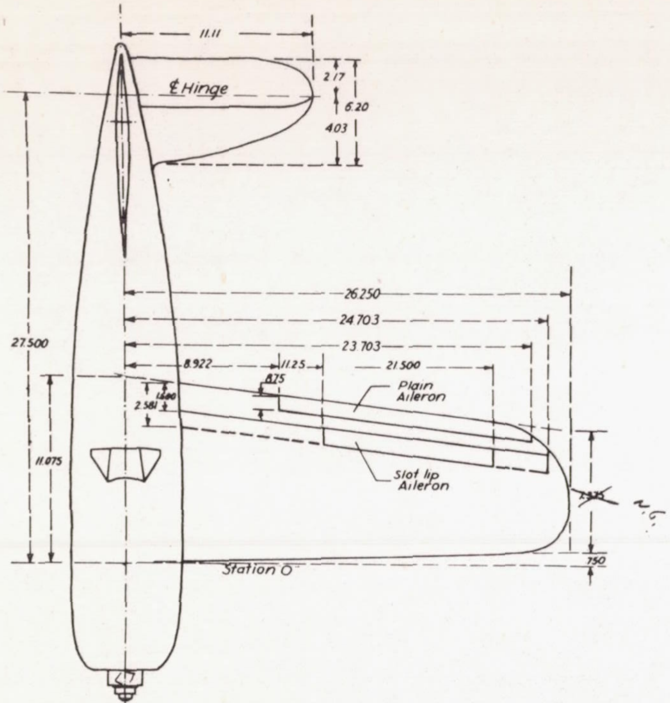
The aerodynamic characteristics of the complete model with both the original and modified wing with various flap deflections are given in figures 2 and 3. The modified wing with the full-span slotted flap increased the maximum lift coefficient about 0.40 above the value for the original wing. The full-span slotted flap failed to give an increase in lift for flap deflections about 40°; this, however, may be caused by the small scale of the model and may not be true on a larger model or the airplane. The increase of diving moment (negative pitching-moment coefficient) with flap deflection is very pronounced with the full-span flaps, whereas there is little change in pitching-moment coefficient with flap deflection on the original wing. From the data of figures 4 and 5, it would require about 4° up elevator to trim the diving moment due to flap deflection on the modified wing. Figures 4 and 5 show that the elevator appears to give sufficient control and shows no evidence of tail stall in the lift range tested. The change in slope of the moment curves, with the full-span flap deflected 50°, at a lift coefficient of about 1.3 is quite large and is undesirable because it indicates lower stability for low-speed flight where the addition of power is also destabilizing.

The rolling- and yawing-moment coefficients for the model with the original wing are given in figures 6, 7, and 8 and for the model with the modified wing in figures 9 to 14. The plain ailerons on the modified wing give approximately the same rolling-moment coefficient as the plain ailerons on the original wing for flap deflections less than 20°, but the plain ailerons on the modified wing give a very substantial increase in adverse yawing-moment coefficient. At high flap deflections the effectiveness of the plain ailerons on the modified wing drops off as has been shown in previous tests.

The rolling- and yawing-moment coefficients for the slot-lip ailerons on the modified wing are shown in figures 15 to 18. The slot-lip ailerons are much more effective than the plain ailerons and become more effective as the flap is deflected. The ratio C_n/C_l for the slot-lip ailerons is more favorable for most cases than the ratio for the plain ailerons on the original wing. It should be noted, however, that there is little change in yawing-moment coefficient with slot-lip aileron deflection in most cases.

The effect of rudder deflection on the aerodynamic characteristics in yaw of the complete model with the modified wing are given in figures 19 and 20. The deflection of the rudder has little effect on the lateral or directional stability. The slope of the yawing-moment curve decreases near zero yaw but still appears to be within the limits set as satisfactory by Commander Diehl in his book "Engineering Aerodynamics."

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., June 21, 1941.



CONSTANTS OF F2A AIRPLANE.

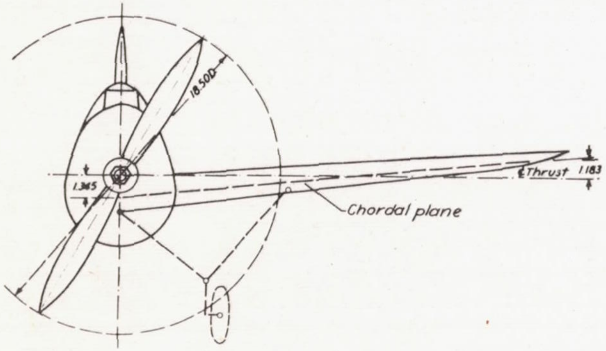
GROSS WEIGHT . . . . . . 6600 LBS.
SPAN . . . . 35.00 FT.
MEAN AERODYNAMIC CHORD 6.24 FT.
AREAS:- WINGS, INCLUDING
AILERON 208.9 SQ.FT.

STABILIZER 30.40 SQ.FT.,
ELEVATOR 19.90 SQ.FT.-TOTAL 50.30 SQ.FT.
ELEVATOR ROOT MEAN SQ.CHORD 1.376 FT.

CG LOCATION (MODEL)

NORMAL FIGHTER; LANDING GEAR RETRACTED.

ARM FROM STA. "0"	ARM FROM ℄ THRUST
2.700 IN.	+.0375 IN.



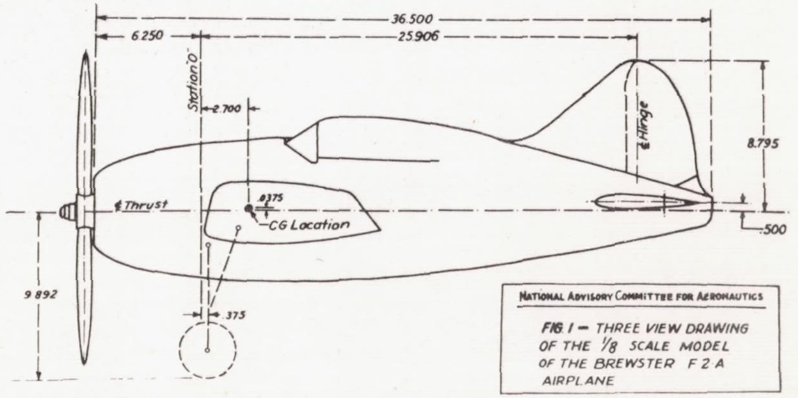


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FIG. 1 — THREE VIEW DRAWING OF THE 1/8 SCALE MODEL OF THE BREWSTER F2A AIRPLANE

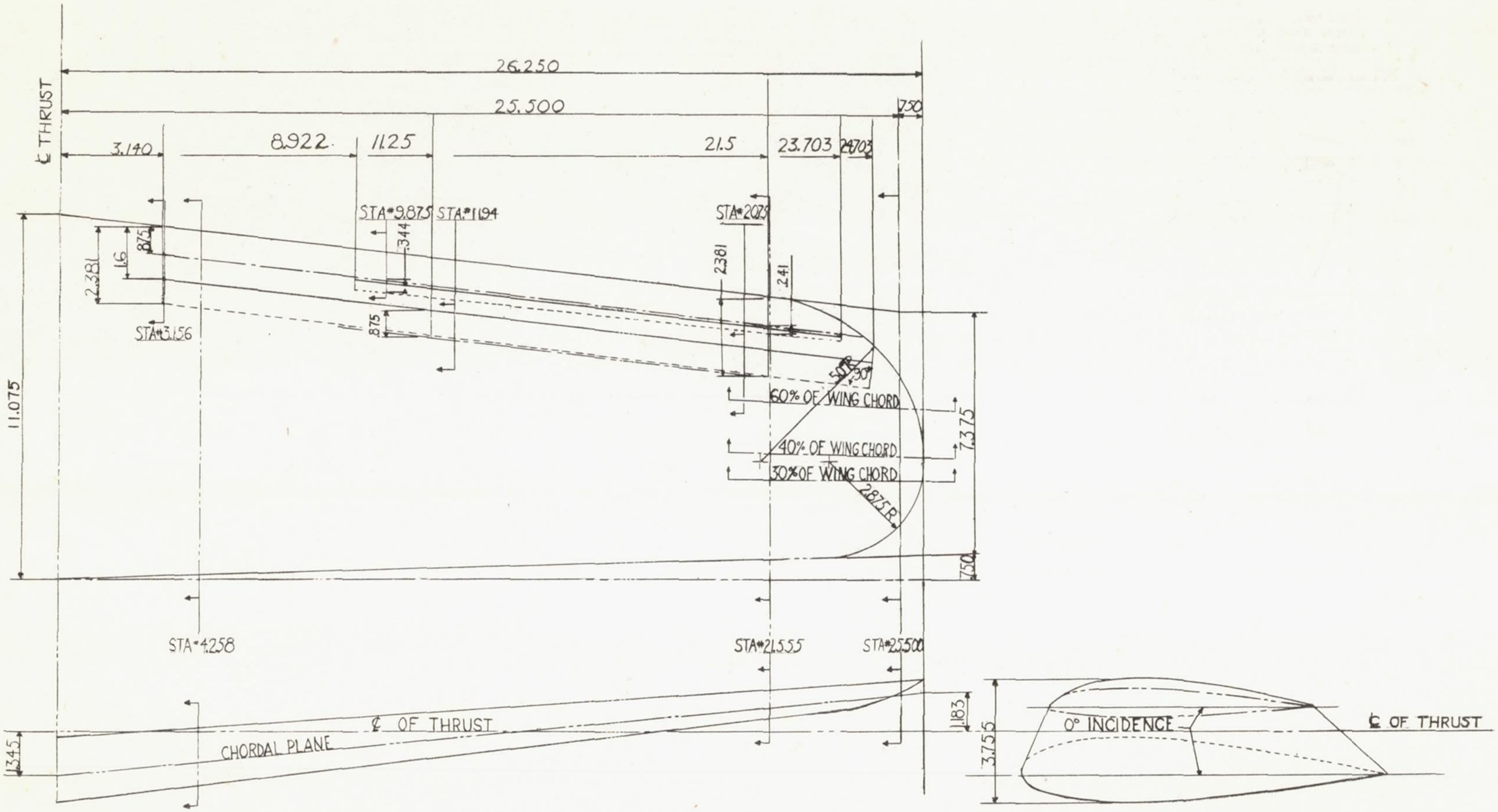

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Figure 1-a – Three view drawing modified wing for $\frac{1}{8}$ scale model Brewster F2A airplane.

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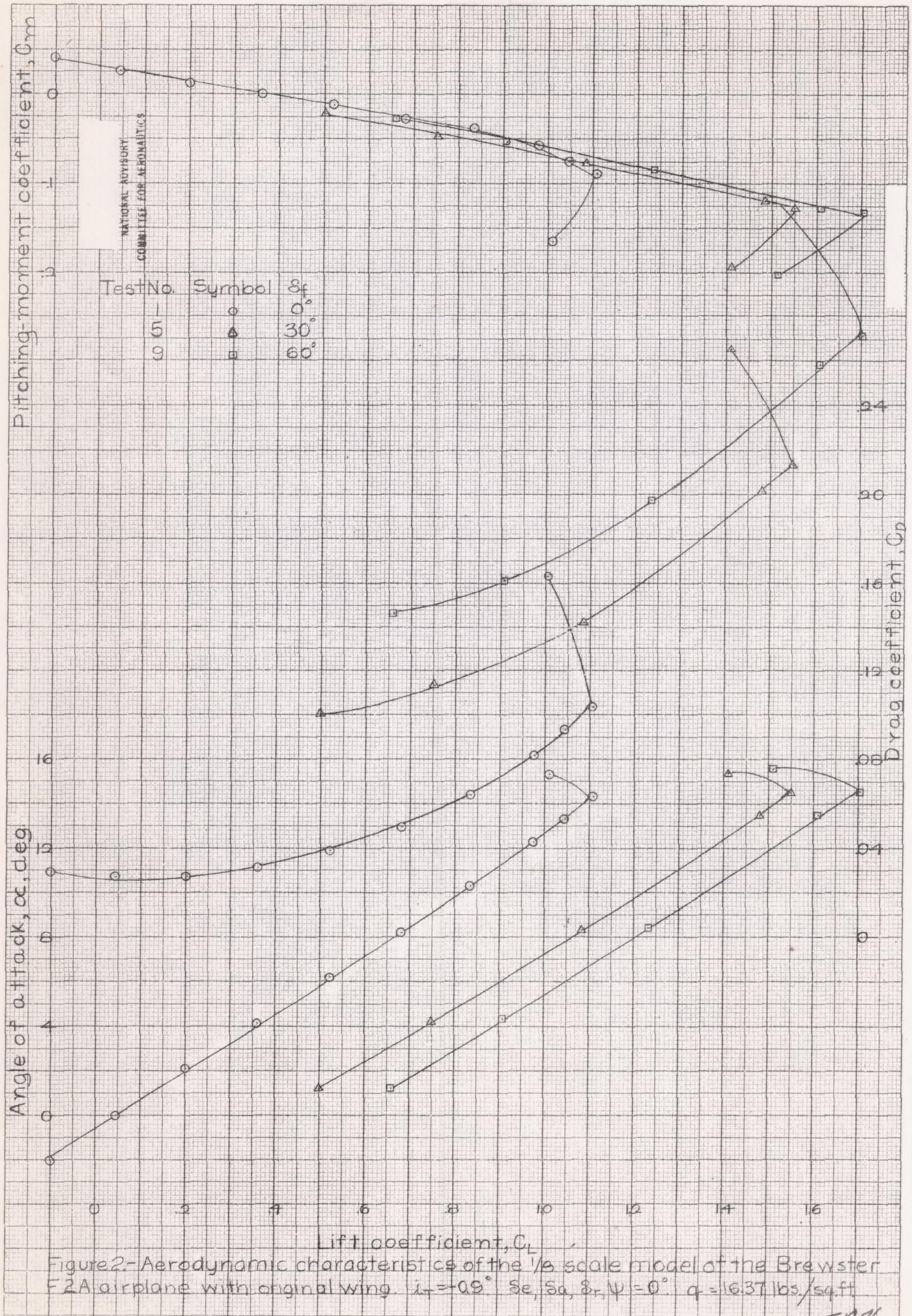

Figure 2.- Aerodynamic characteristics of the 1/8 scale model of the Brewster F2A airplane with original wing. $i_t = -0.8°$ $\delta_e, \delta_a, \delta_r, \psi = 0°$ $q = 16.37$ lbs./sq.ft

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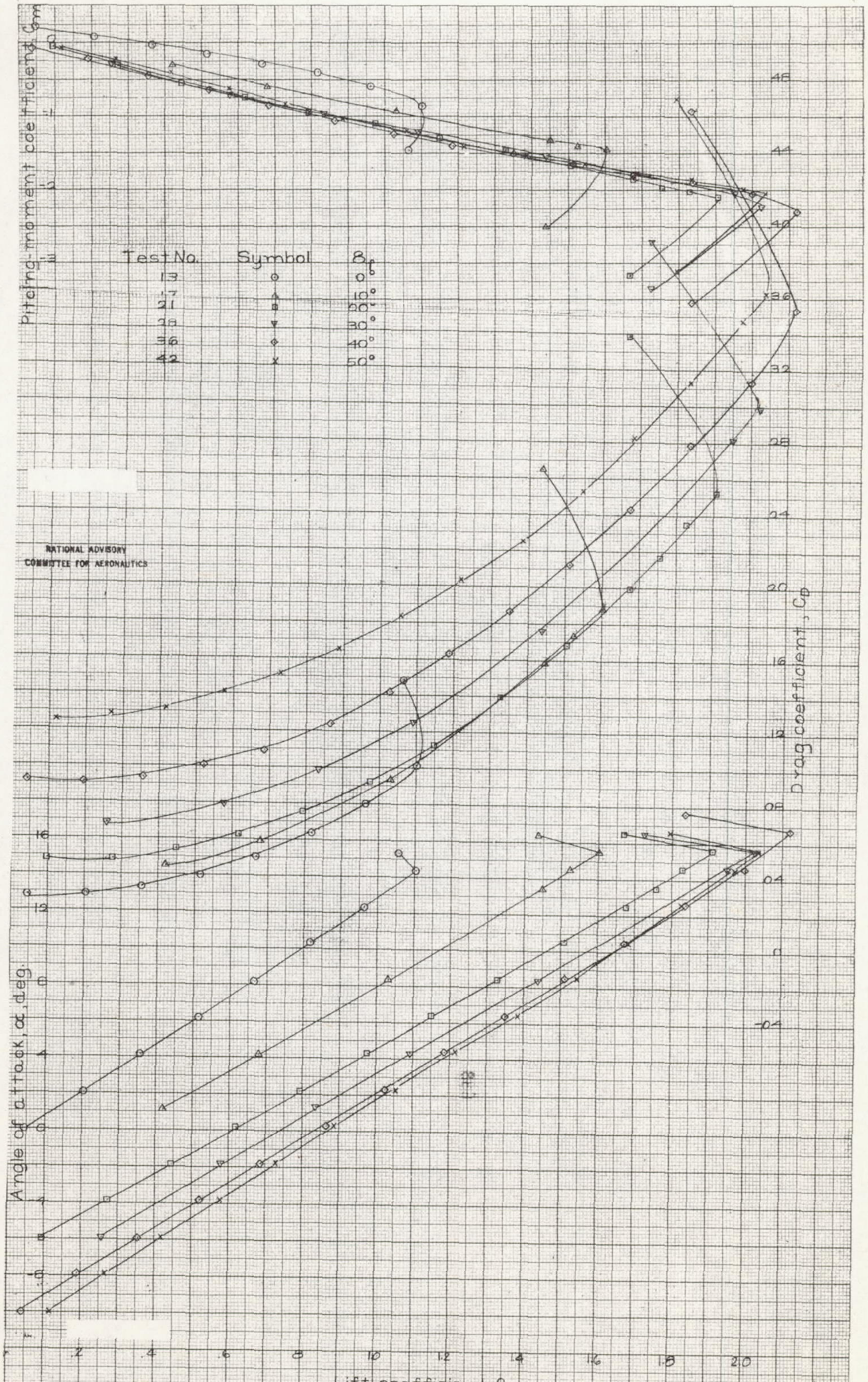

Figure 3.- Aerodynamic characteristics of the 1/8 scale model of the Brewster F2A airplane with modified wing. $\delta_e, \delta_a, \delta_r, \psi = 0°$
$q = 16.37$ lbs/sq ft

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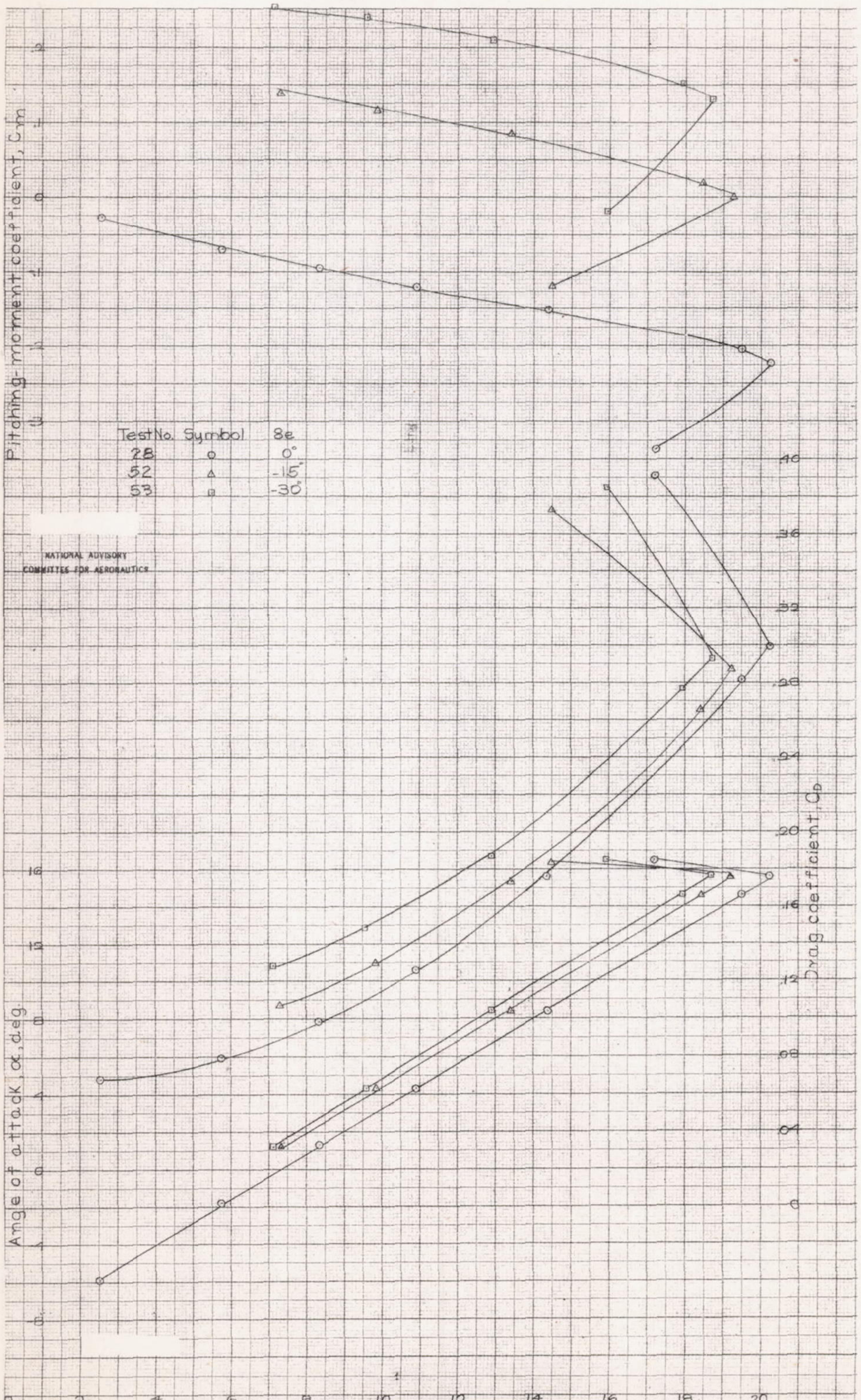

Figure 4.- Effect of elevator deflection on the aerodynamic characteristics of the 1/8 scale model of the Brewster F2A airplane with modified wing. $i_t = -0.9°$ $\delta_a, \delta_r, \psi = 0°$ $\delta_f = 30°$ $q_c = 16.37$ lb/sq ft.

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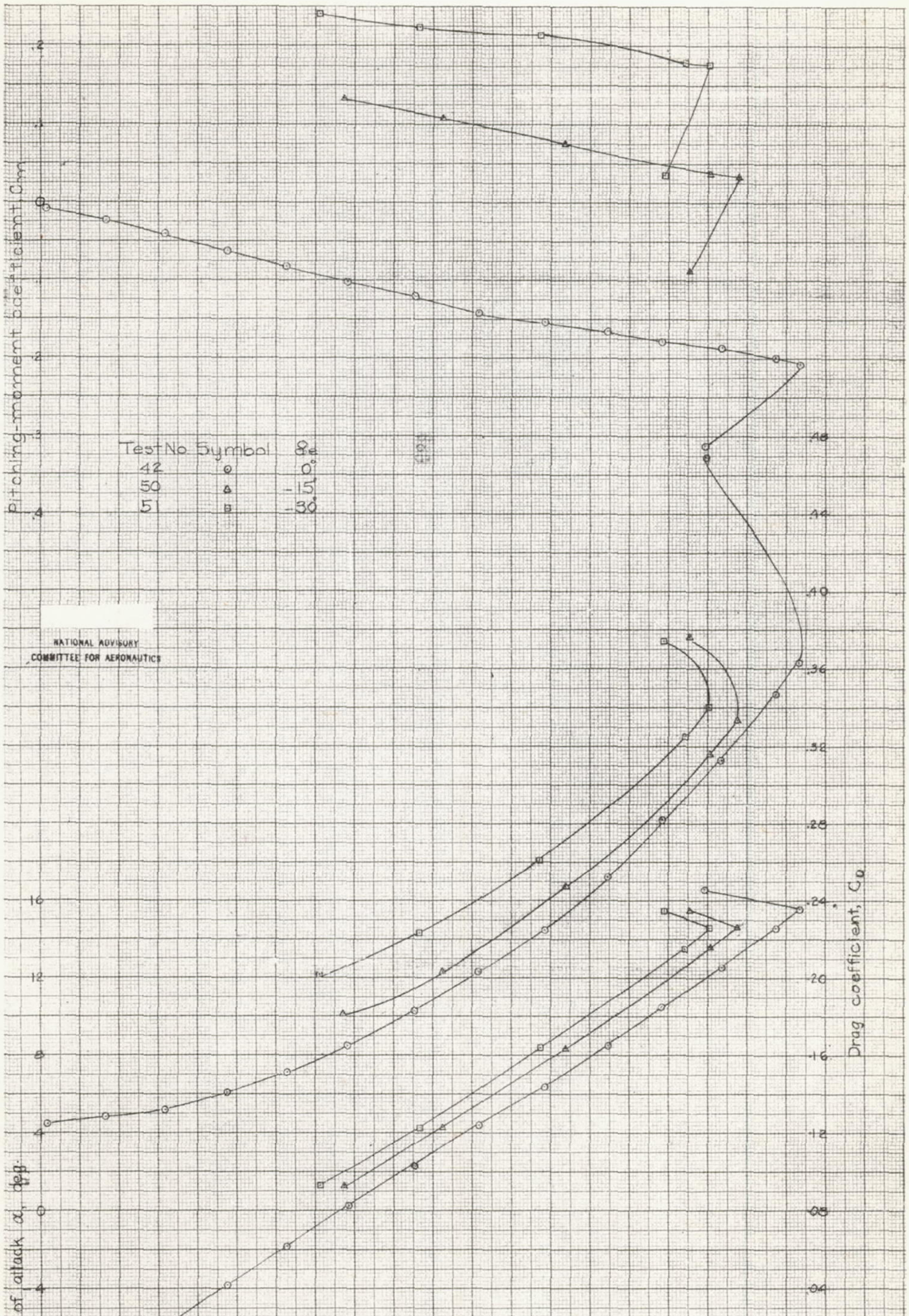

Figure 5.– Effect of elevator deflection on the aerodynamic characteristics of the 1/8 scale model of the Brewster F2A airplane with modified wing. $\delta_a, \delta_r, \psi = 0°$. $\delta_f = 50°$ $q = 16.37$ lbs/sq.ft.

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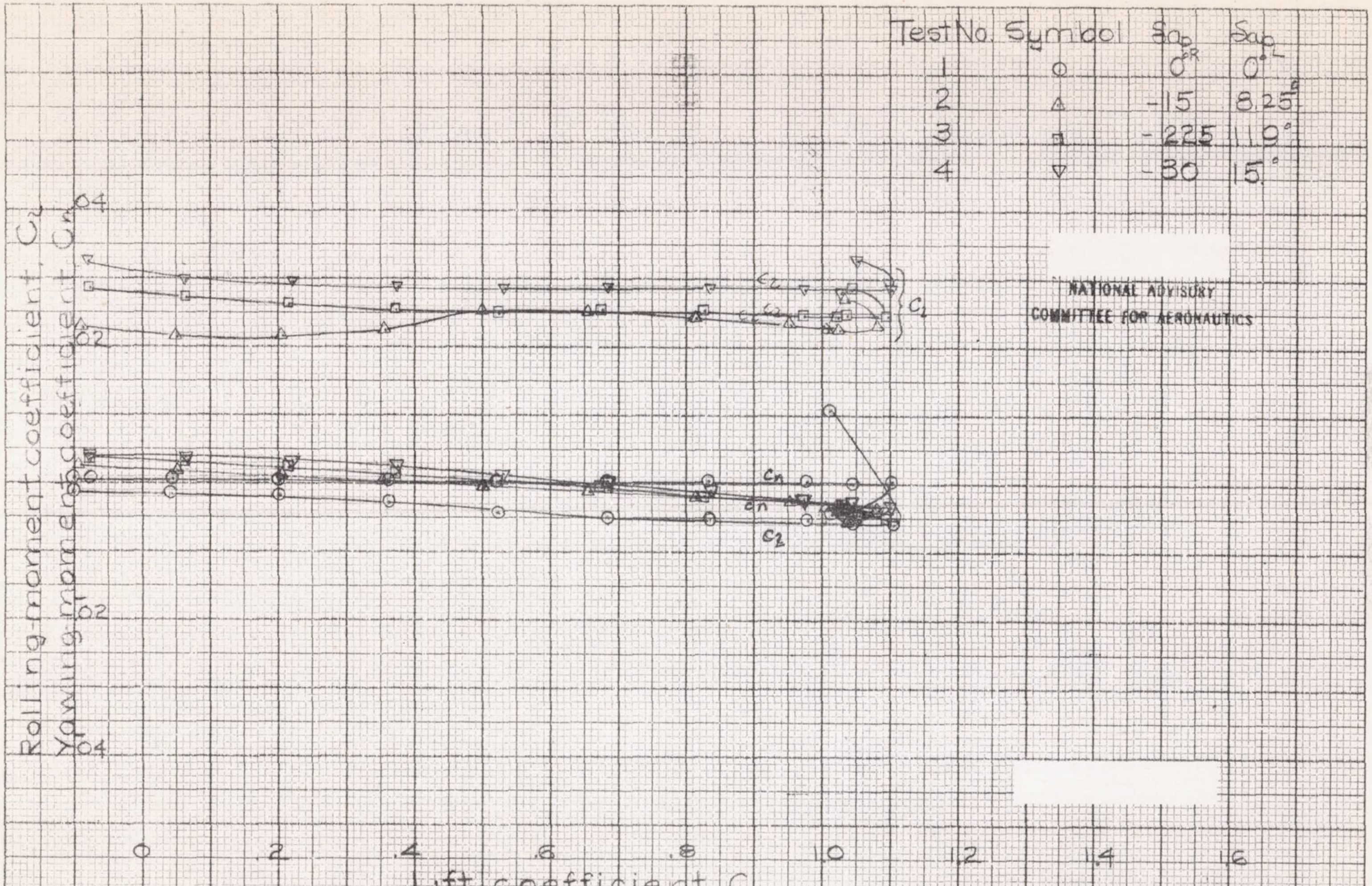

Figure 6.- Effect of aileron deflection on the rolling and yawing-moment coefficients of the 1/8 scale model of the Brewster F2A airplane with original wing. $i_t = -0.9°$ $\delta_e, \delta_r, \psi = 0°$ $\delta_f = 0°$ $q = 16.37$ lbs/sq ft.

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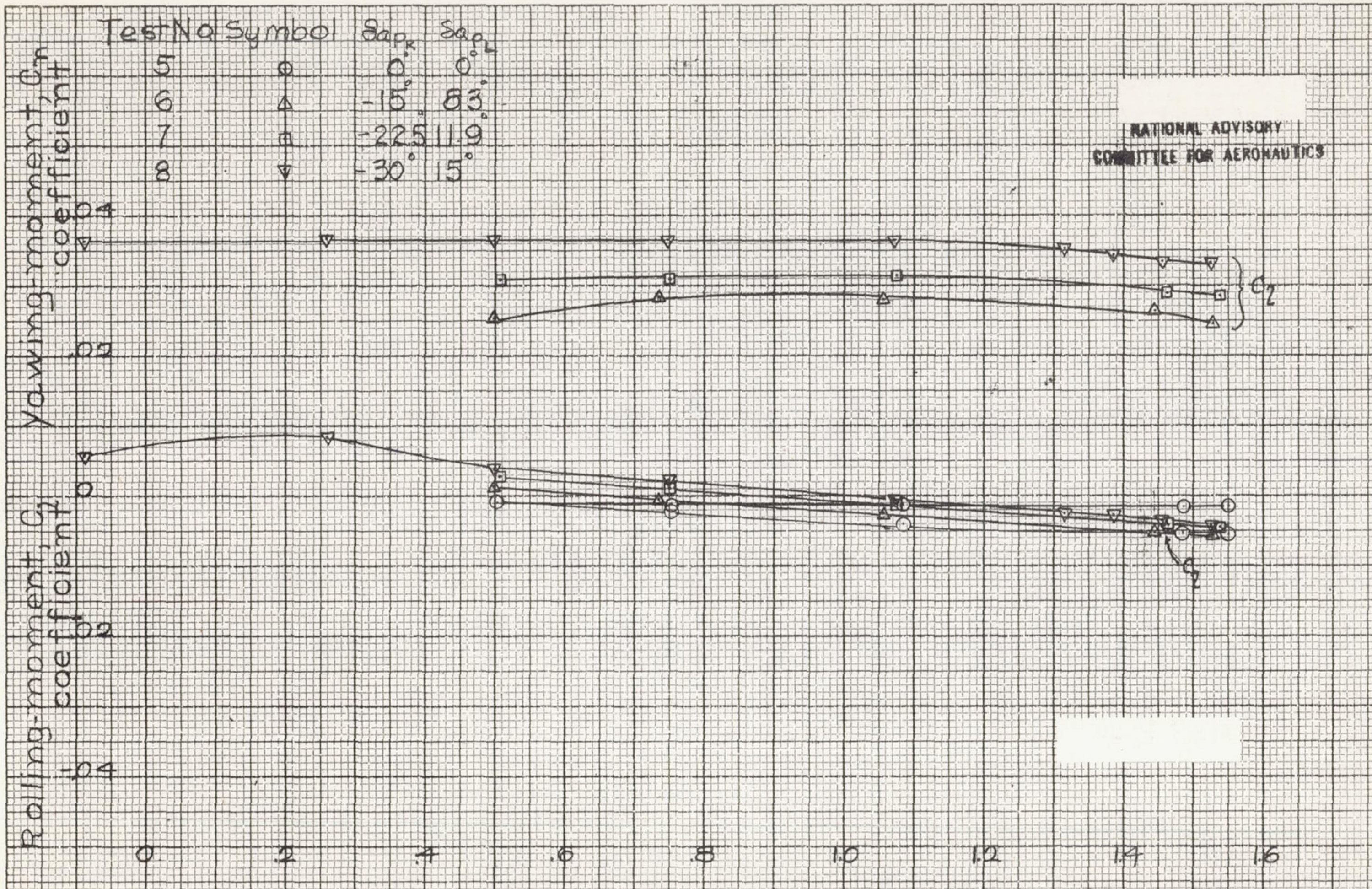

Figure 7.- Effect of aileron deflection on the rolling- and yawing-moment coefficients of the 1/8 scale model of the Brewster F2A airplane with original wing. $i_T = -0.9°$, $\delta_e, \delta_r, \psi = 0°$, $\delta_f = 30°$, $q = 16.37$ lbs/sq.ft.

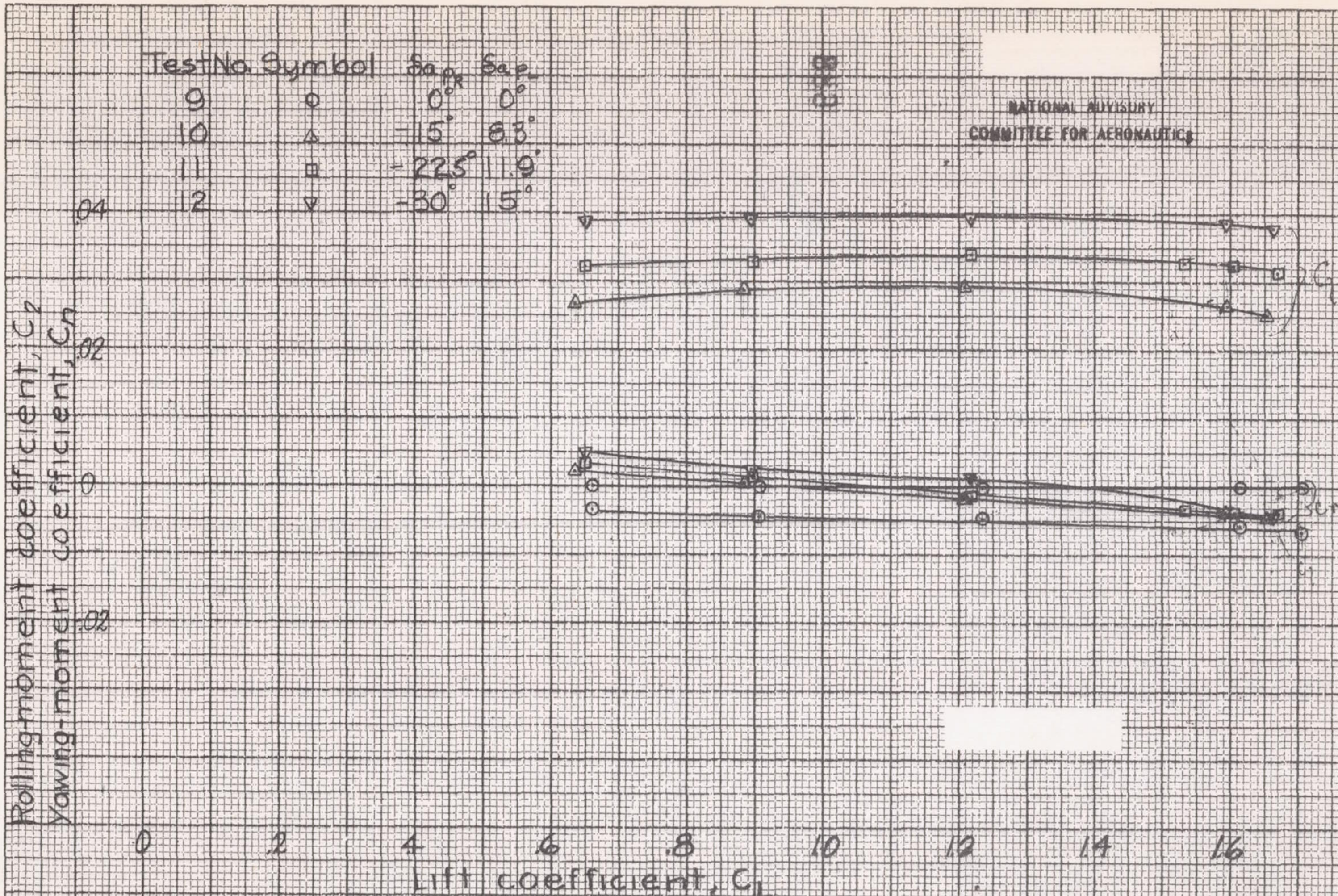

Figure 8.- Effect of aileron deflection on the rolling- and yawing-moment coefficients of the 1/8 scale model of the Brewster F2A airplane with original wing. $i_T = -0.9°$. $\delta_e, \delta_r, \psi = 0°$. $\delta_f = 60°$. $q = 16.37$ lbs/sq ft

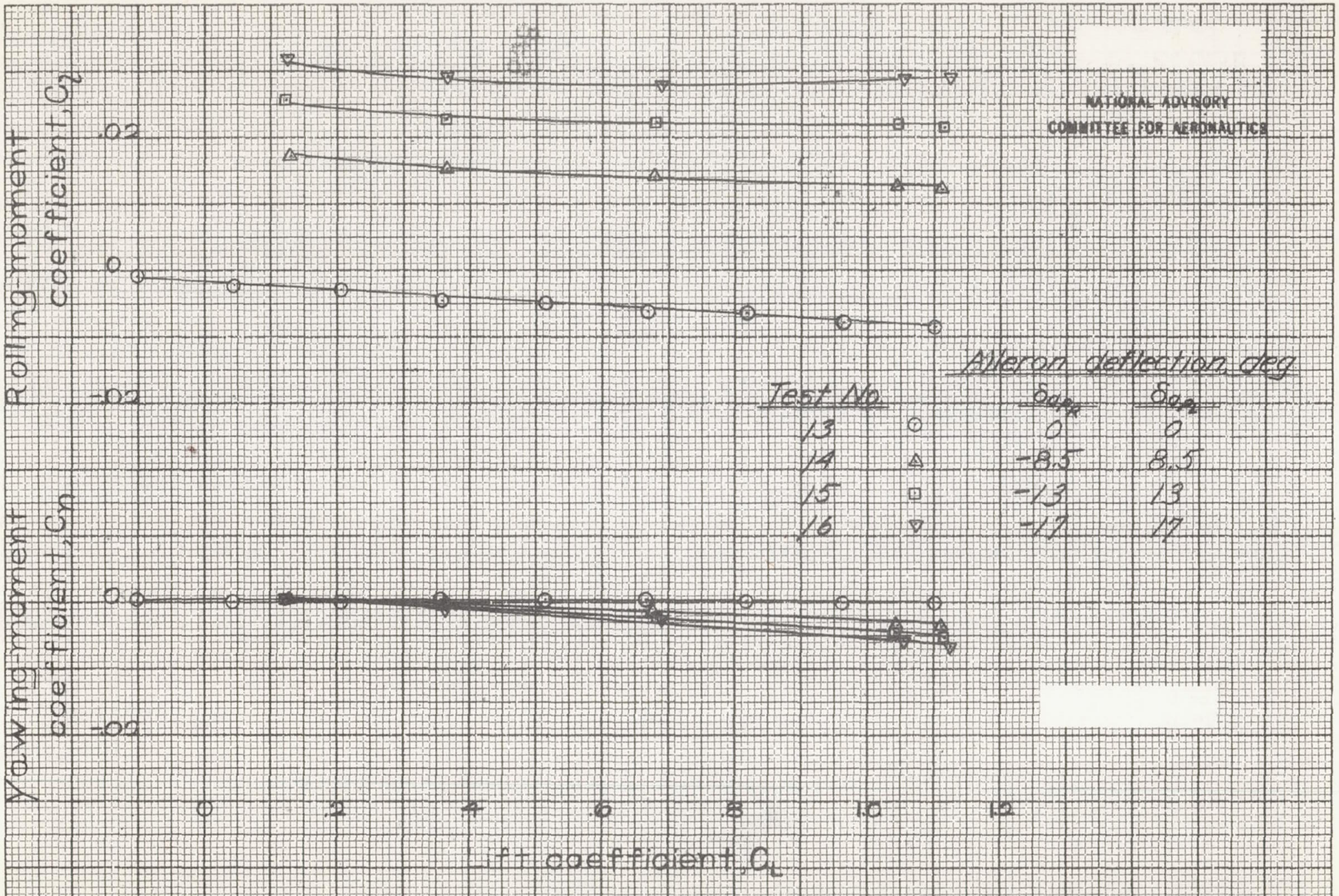

FIGURE 9.-Effect of plain aileron deflection on the yawing- and rolling-moment coefficients of the $\frac{1}{8}$ scale model of the Brewster F2A airplane with modified wing. $i_T = -0.9°$, $\delta_{a_{S_L}} = \delta_e = \delta_r = \psi = 0°$, $\delta_f = 0°$, $q = 16.37$ lbs/sq. ft.

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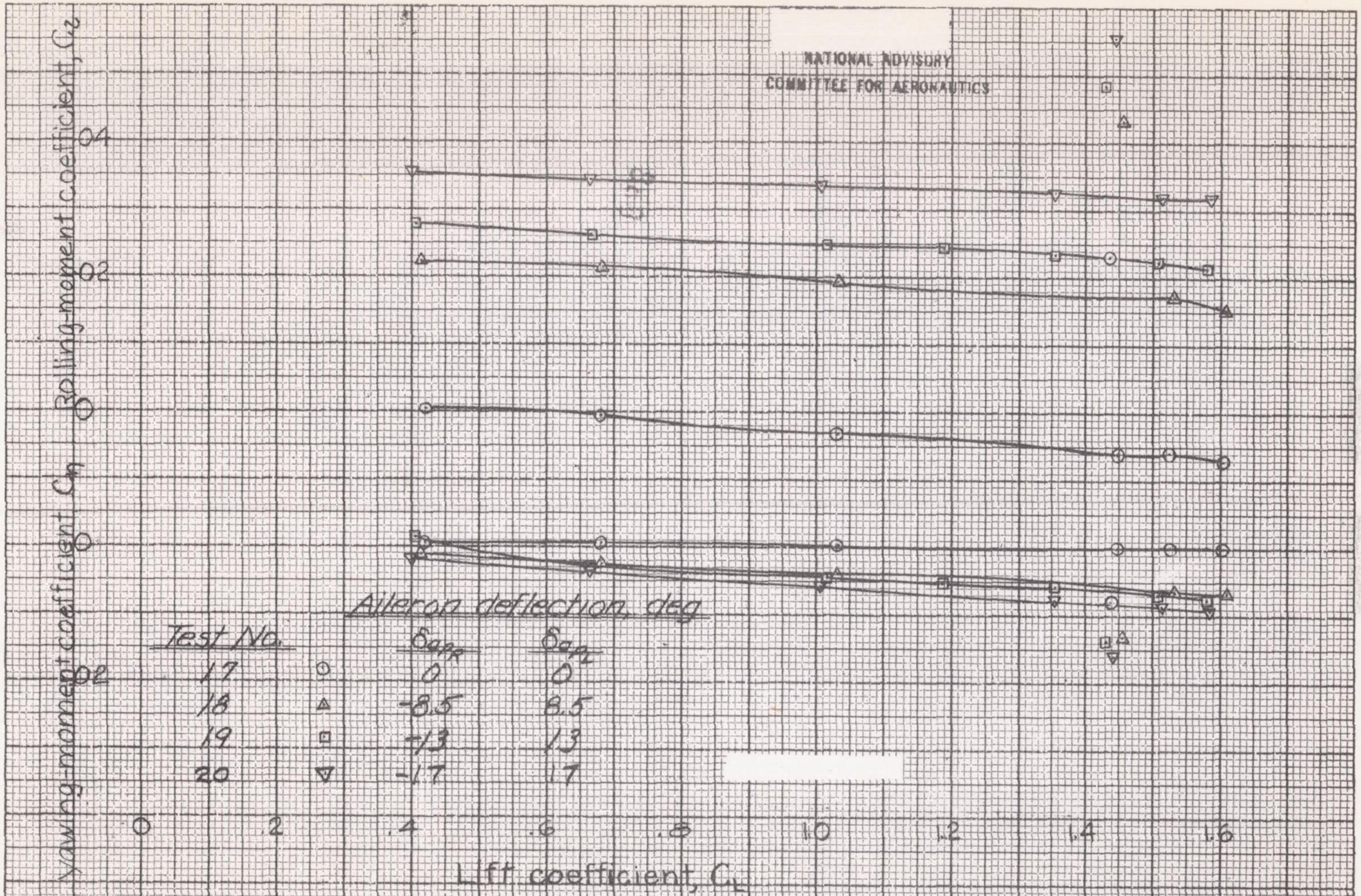

Figure 10.-Effect of plain aileron deflection on the yawing- and rolling-moment coefficients of the $\frac{1}{8}$ scale model of the Brewster F2A airplane with modified wing. $i_T = -0.9°$; $\delta_{a_{SL}} = \delta_e = \delta_r = \psi = 0°$; $\delta_f = 10°$; $q = 16.37$ lbs/sq.ft.

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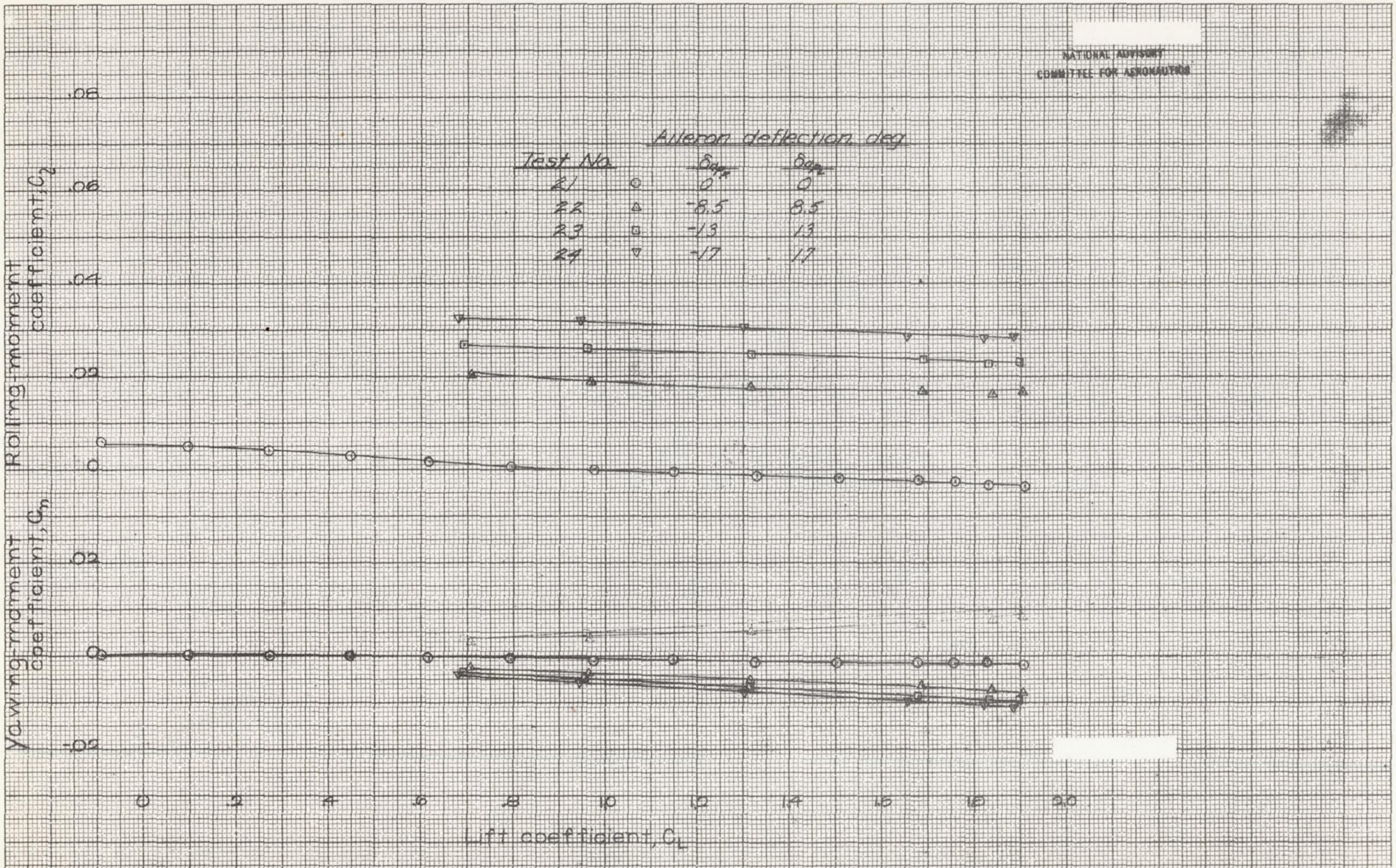

Figure 14.- Effect of plain aileron deflection on the yawing- and rolling-moment coefficients of the $\frac{1}{8}$ scale model of the Brewster F2A airplane with modified wing. $i_T = -0.9°$, $\delta_{a_{SL}} = \delta_e = \delta_r = \psi = 0°$; $\delta_f = 20°$; $q = 16.37$ lbs/sq.ft.

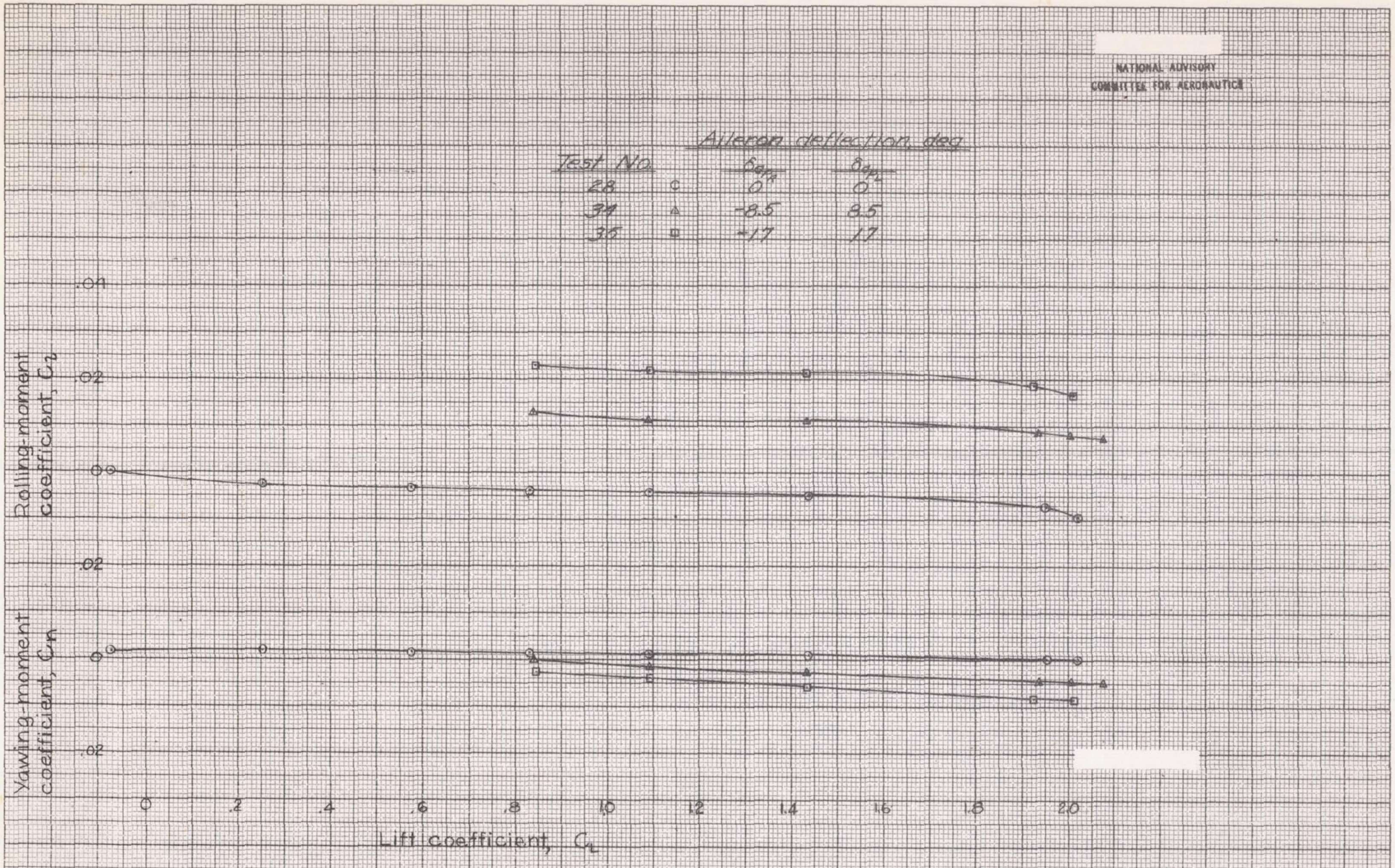

FIGURE 12- Effect of plain aileron deflection on the yawing- and rolling-moment coefficients of the $\frac{1}{8}$ scale model of the Brewster F2A airplane with modified wing. $i_T=-0.9°$; $\delta_{a_{SL}}=\delta_e=\delta_r=\psi=0°$; $\delta_f=30°$; $q=16.37\ lbs/sq\ ft$.

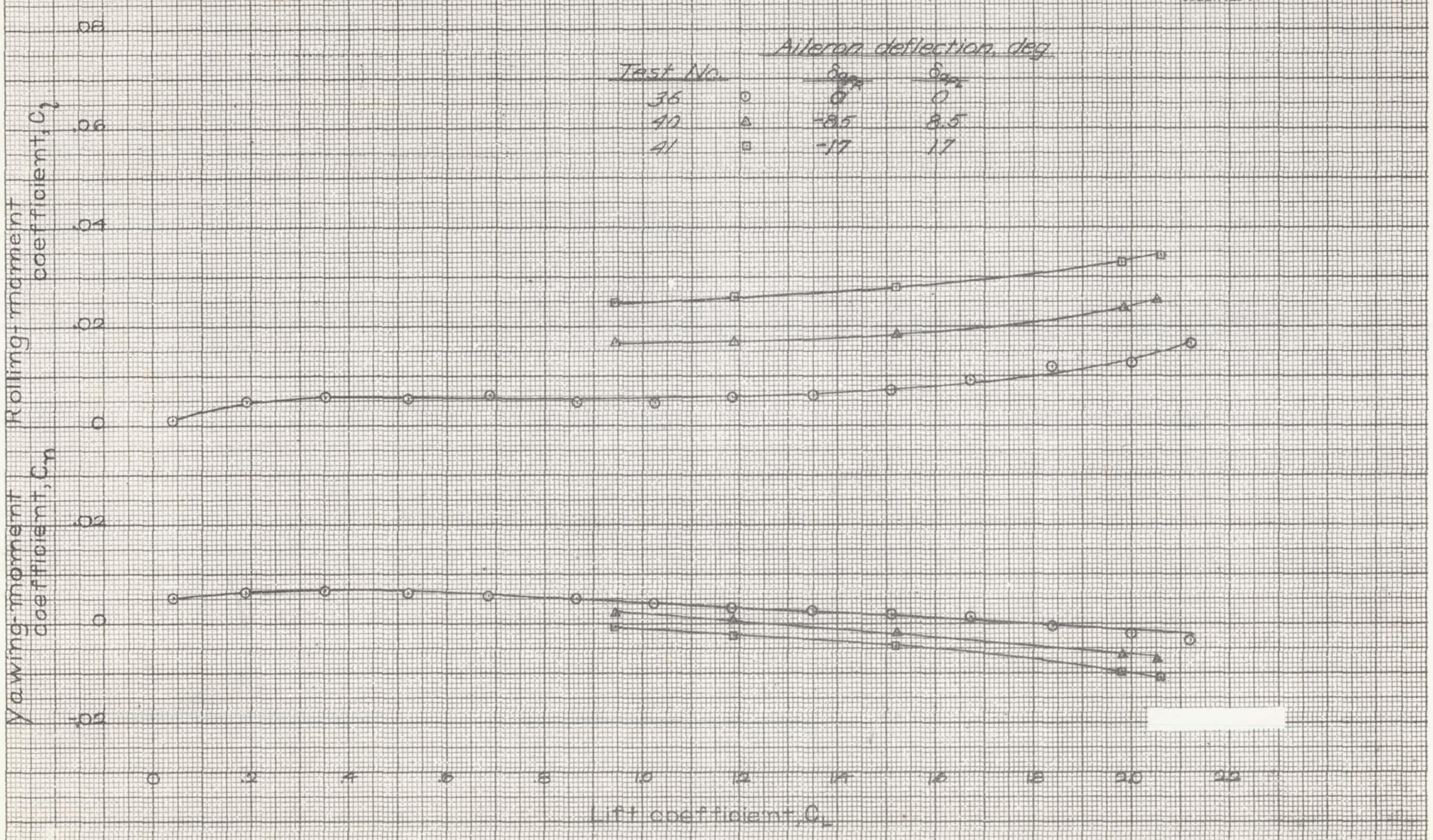

FIGURE 13.-Effect of plain aileron deflection on the yawing- and rolling-moment coefficients of the $\frac{1}{8}$ scale model of the Brewster F2A airplane with modified wing. $i_t = -0.9°$, $\delta_{a_{SL}} = \delta_e = \delta_r = \psi = 0°$, $\delta_f = 40°$, $q = 16.37$ lb/sq ft

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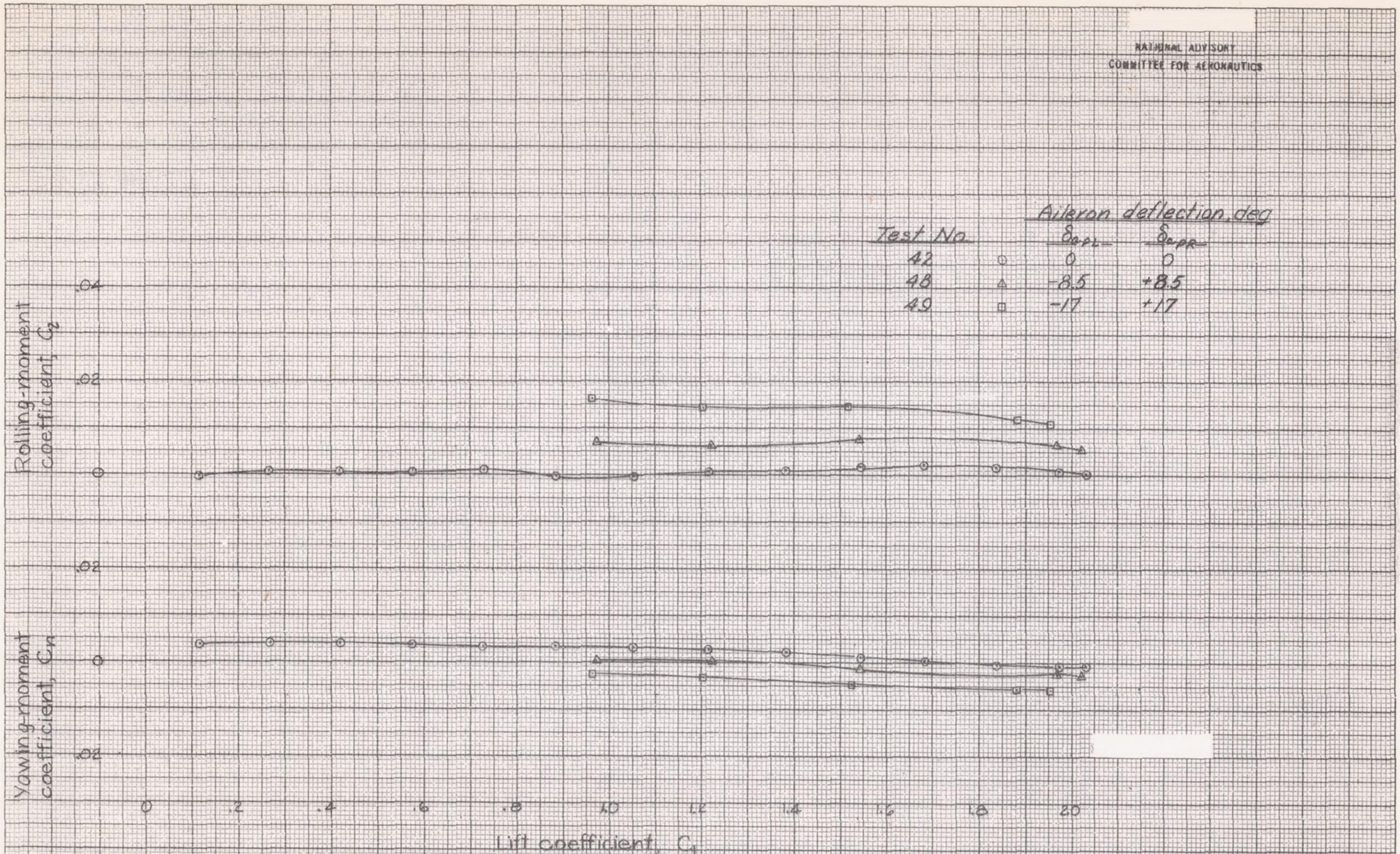

Figure 14.-Effect of plain aileron deflection on the yawing- and rolling-moment coefficients of the $\frac{1}{8}$ scale model of the Brewster F2A airplane with modified wing $i_T = -0.9°$, $\delta_{a_{SL}} = \delta_e = \delta_r = \psi = 0°$, $\delta_f = 50°$, $q = 16.37$ lbs/sq ft.

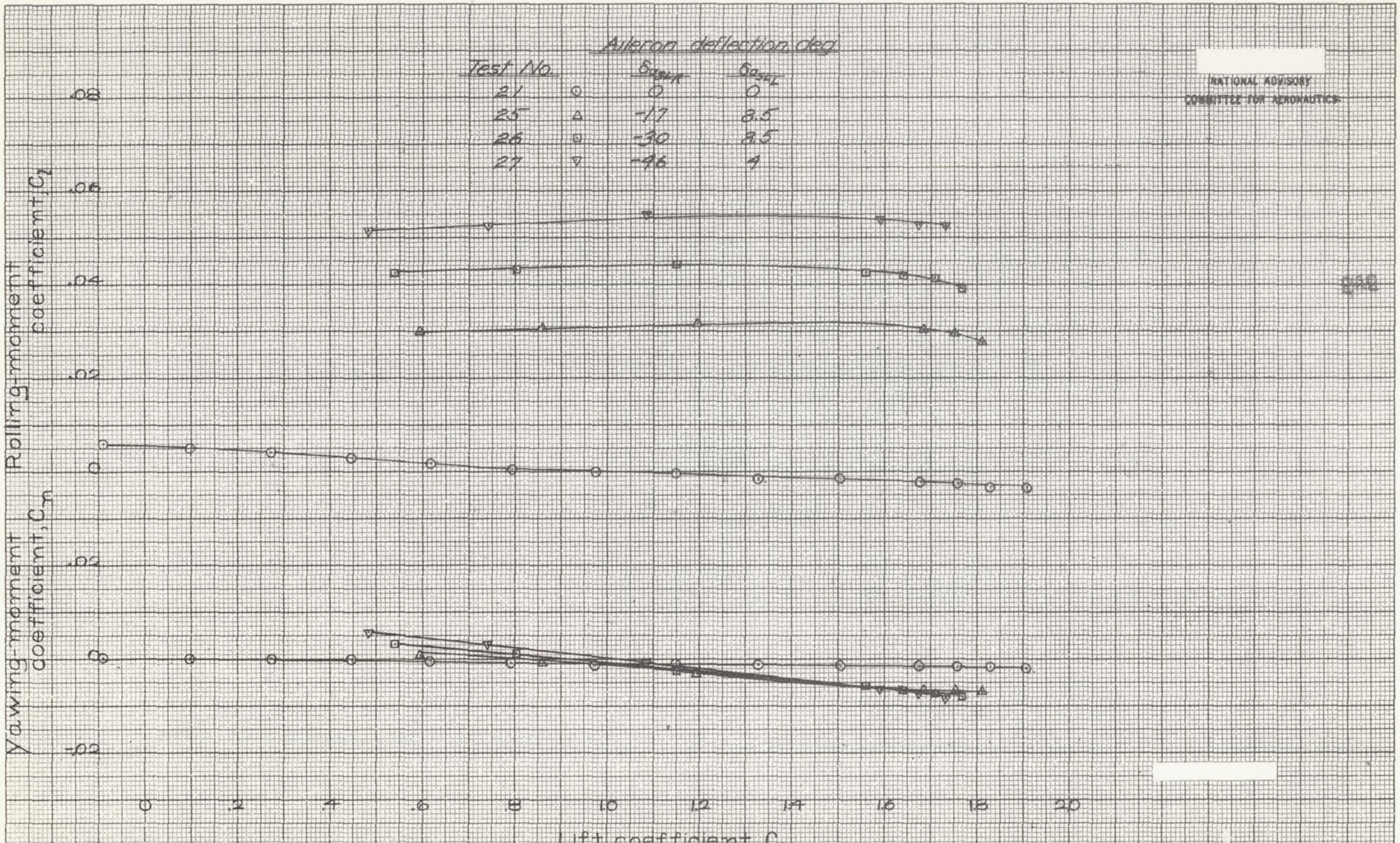

Figure 15.- Effect of slot-lip aileron deflection on the rolling- and yawing-moment coefficients of the $\frac{1}{8}$ scale model of the Brewster F2A airplane with modified wing. $\delta_{a_p}, \delta_e, \delta_r, \psi = 0°$ $\delta_f = 20°$, $q = 16.37$ lbs/sq.ft., $i_t = -9°$

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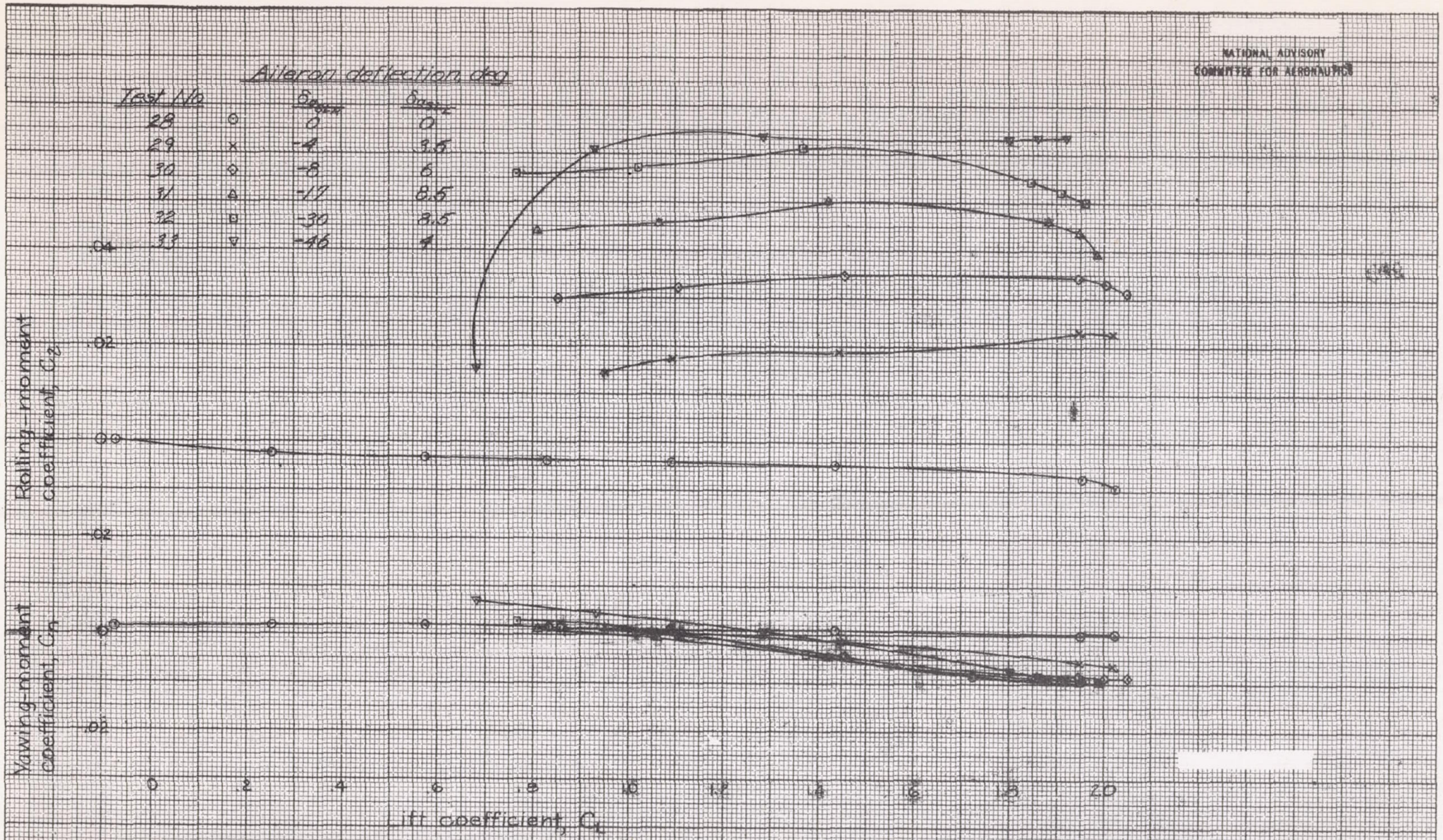

FIGURE 16.- Effect of slot-lip aileron deflection on the rolling- and yawing-moment coefficients of the $\frac{1}{8}$ scale model of the Brewster F2A airplane with modified wing. δ_{a_p}, δ_e, δ_r, $\psi = 0°$, $\delta_f = 30°$ $q = 16.37$ lbs/sq ft, $i_t = -3°$

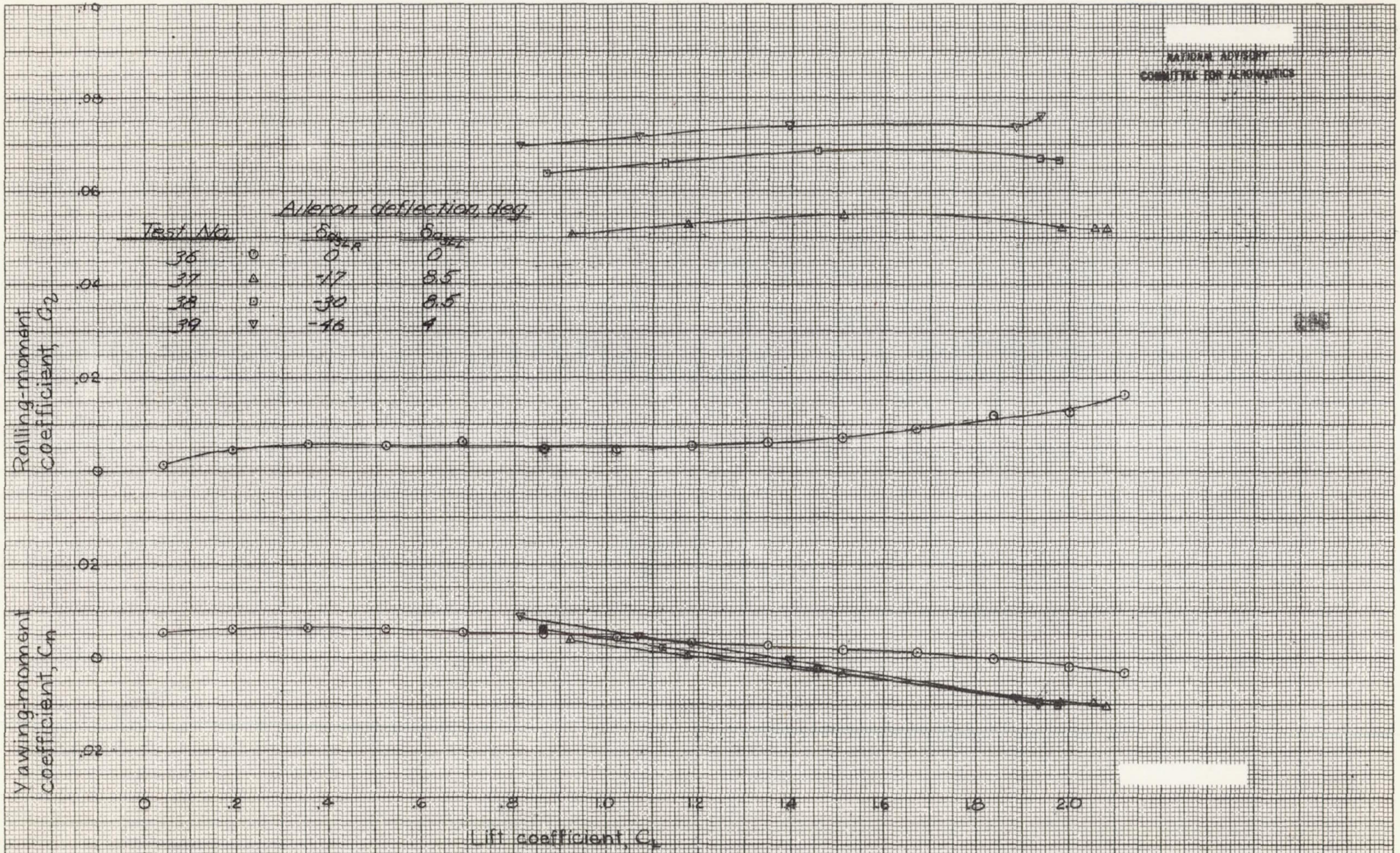

FIGURE 17.- Effect of slot-lip aileron deflection on the rolling- and yawing-moment coefficients of the $\frac{1}{8}$ scale model of the Brewster F2A airplane with modified wing. $\delta_{a_p}, \delta_e, \delta_r, \psi = 0$, $\delta_f = 40°$ $q = 16.37$ lbs/sq ft, $i_t = -9°$

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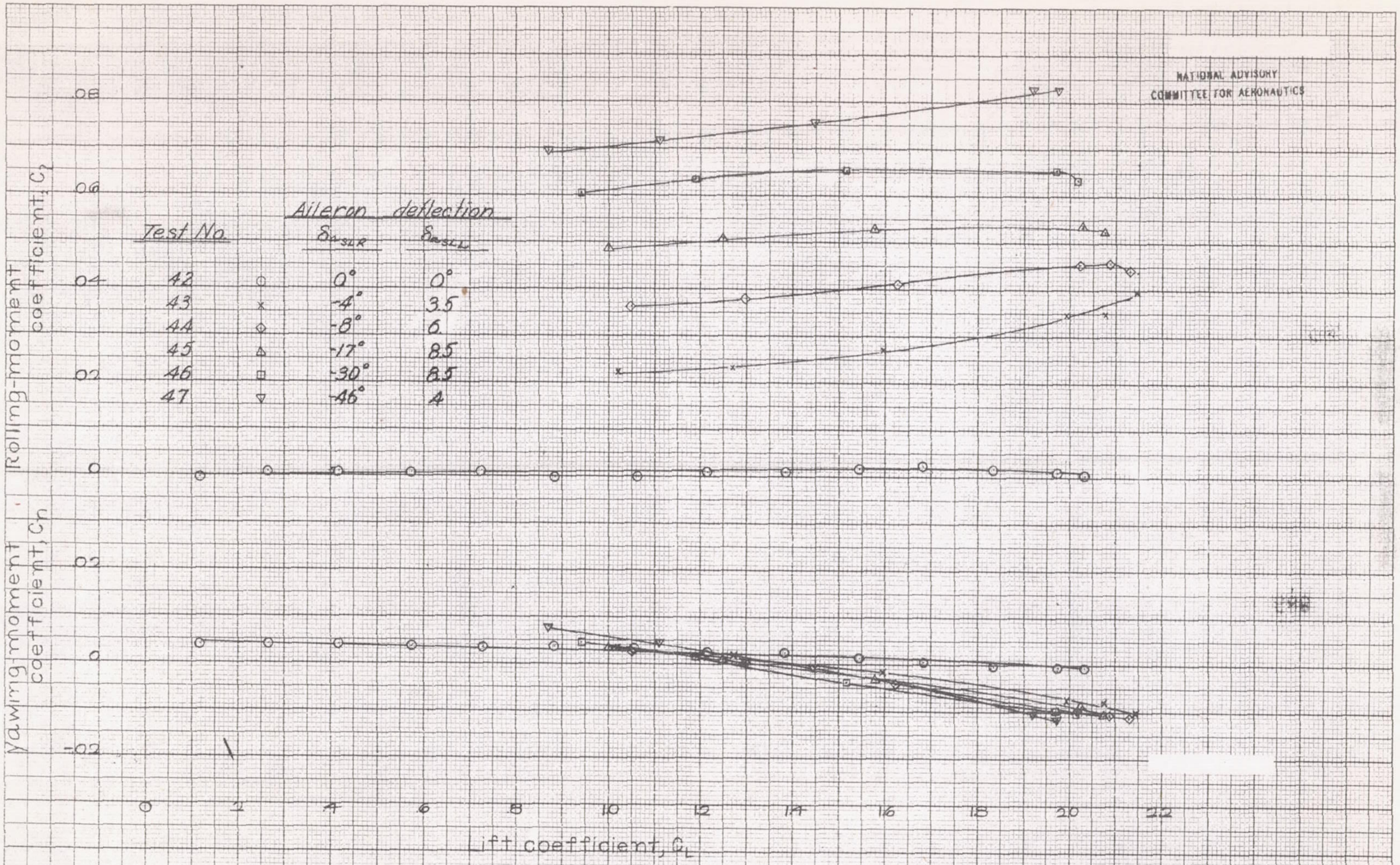

FIGURE 18.- Effect of slot-lip aileron deflection on the rolling- and yawing-moment coefficients of the $\frac{1}{8}$ scale model of the Brewster F2A airplane with modified wing. $\delta_{a_p}, \delta_e, \delta_r, \psi = 0°$, $\delta_f = 50°$ $q = 16.37$ lbs/sq.ft., $i_t = -0.9°$

T.A.H.
6-7-41

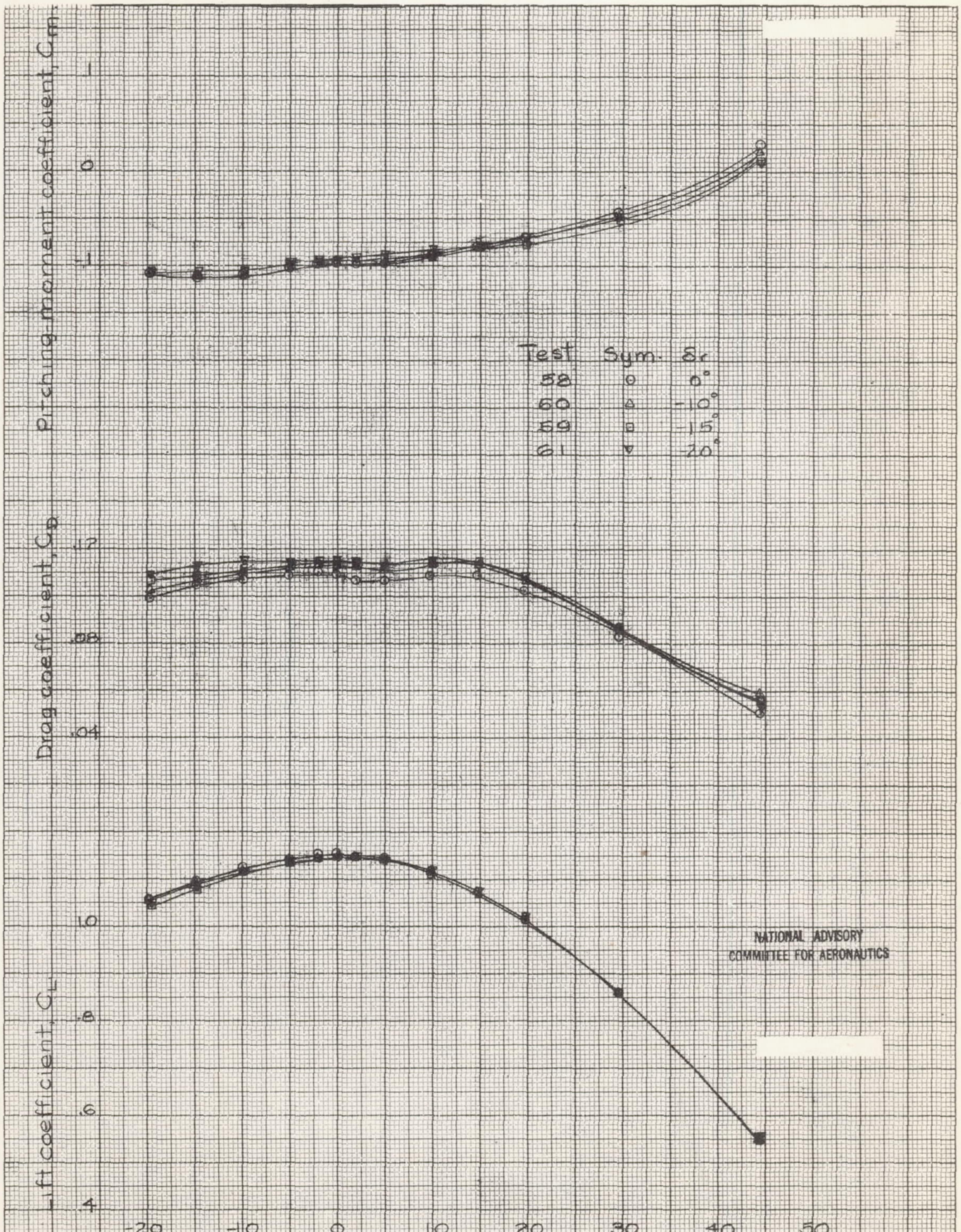

Figure 19.- Effect of rudder deflection on the aerodynamic characteristics in yaw of the 1/8 scale model of the Brewster F2A airplane with modified wing. Climbing condition, $\alpha = 10°$, $\delta_f = 10°$ δ_{a_L} δ_{a_R} $\delta_e = 0°$ $i_t = -0.9°$ $q = 16.37$ lbs/sq. ft

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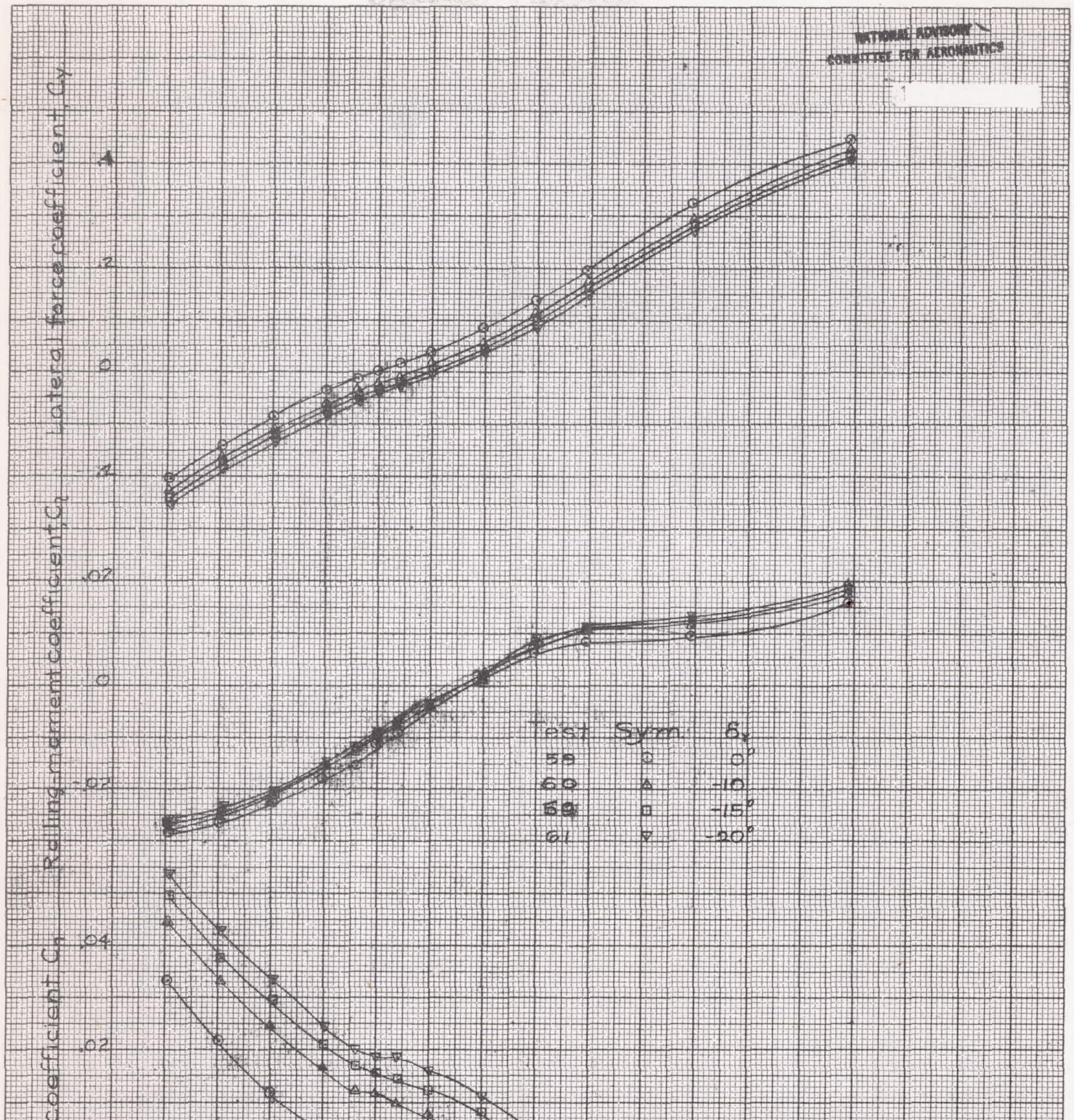

Figure 19 (cont)-Effect of rudder deflection on aerodynamic characteristics in yaw of the 1/8 scale model of the Brewster F2A airplane with modified wing. Climbing condition, $\alpha = 10°$, $\delta_f = 10°$, $\delta_{a_{L}}$ 8°, δ_{a_R} 8°, $\delta_e = 0°$ $i_t = -2.9°$ q = 16.37 lbs/sq. ft.

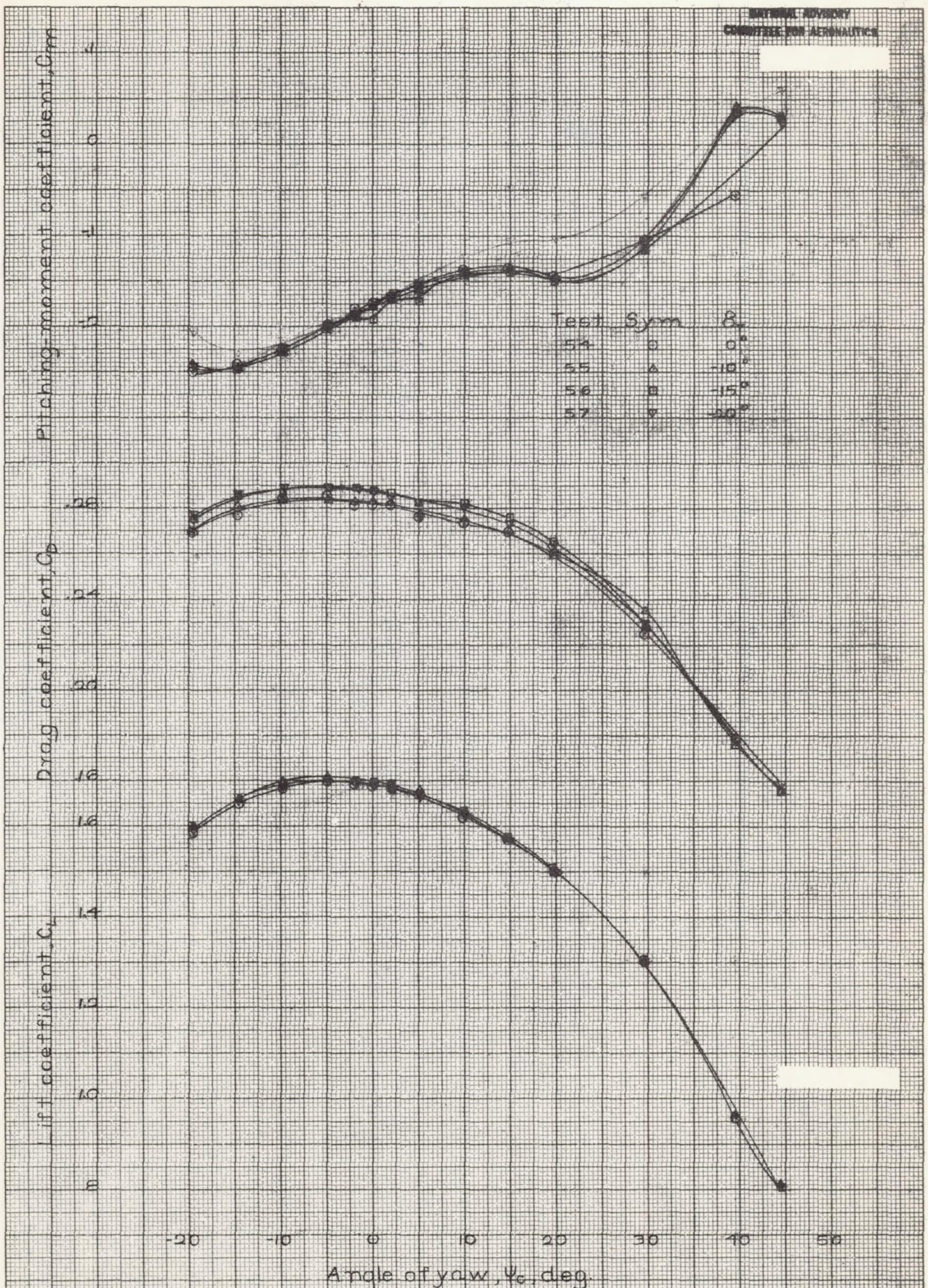

Figure 20- Effect of rudder deflection on aerodynamic characteristics in yaw of the 1/6 scale model of the Brewster F2A airplane with modified wing. Climbing condition, $\alpha=10°$ $\delta_f=50°$, δ_{a_L}, δ_{a_R}, $\delta_e=0°$ $i_t=-0.9°$ $q=16.37$ lb/sq.ft

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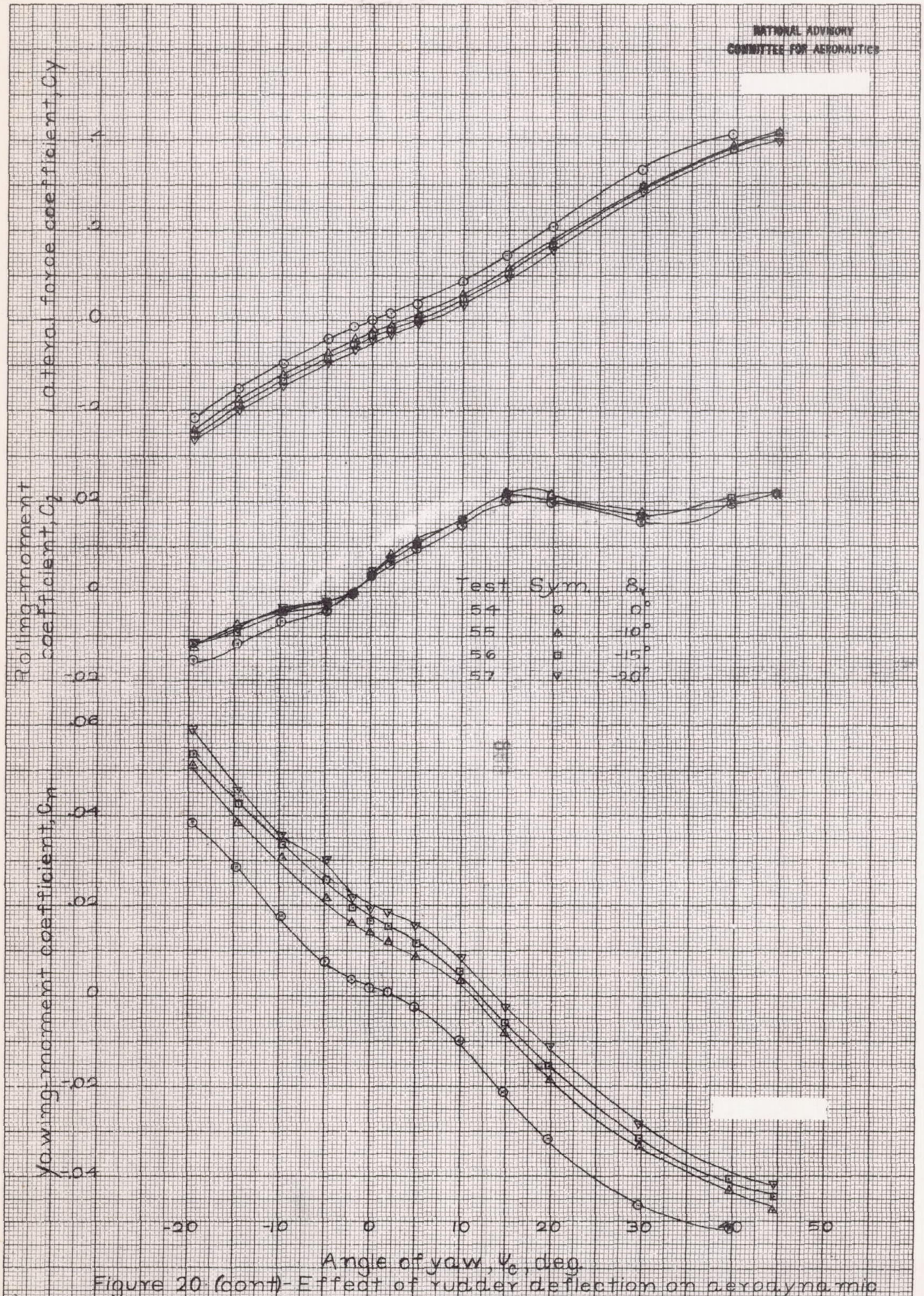

Figure 20 (cont)- Effect of rudder deflection on aerodynamic characteristics in yaw of the 1/8 scale model of the Brewster F2A airplane with modified wing. Climbing condition, $\alpha = 10°$ $\delta_f = 50°$, δ_{a_L}, δ_{a_R}, $\delta_e = 0°$ $i_t = -0.9°$. $q = 16.37$ lb/sq ft

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